

(12) UK Patent Application (19) GB (11) 2 382 748 (13) A

(43) Date of A Publication 04.06.2003

(21) Application No 0128475.1

(22) Date of Filing 28.11.2001

(71) Applicant(s)  
IPWireless Inc  
(Incorporated in USA - Delaware)  
1001 Bayhill Drive 2nd Floor, San Bruno,  
California 94066, United States of America

(72) Inventor(s)  
Nicholas William Anderson

(74) Agent and/or Address for Service  
Peter Hudson  
InetIP, 121 Blackberry Lane, Four Marks,  
ALTON, Hampshire, GU34 5DJ,  
United Kingdom

(51) INT CL<sup>7</sup>  
H04B 17/00 7/005, H04L 1/20

(52) UK CL (Edition V )  
H4L LFMA L213

(56) Documents Cited  
WO 2002/025853 A2 WO 2001/082521 A1  
WO 2001/020789 A1 WO 1999/046869 A1  
US 6028894 A US 5737365 A

(58) Field of Search  
UK CL (Edition T ) H4L LDTP LFMA LFMX, H4P PEM  
INT CL<sup>7</sup> H04B 1/10 1/707 7/005 7/08 17/00, H04L 1/20,  
H04Q 7/32 7/38  
Other: ONLINE: WPI, JAPIO, EPODOC, INSPEC

(54) Abstract Title  
Signal to noise plus interference ratio (SNIR) estimation with corection factor

(57) A method, arrangement and communication receiver for SNIR estimation of a received signal, by:  
deriving an estimation  $\hat{Z}$  of SNIR of the received signal in accordance with the relation  $\hat{Z} = \frac{[E\{r(t)\}]^2}{E\{r^2(t)\} - [E\{r(t)\}]^2}$ ,

where E represents mean value and r(t) represents the level of the received signal; and correcting the

estimation  $\hat{Z}$  to produce a corrected estimation Z based on the relation  $Z = \alpha(\hat{Z}) \times \hat{Z}$ , where

$\alpha(\hat{Z})$  represents a correction factor. The estimation may be corrected by calculating the correction factor, retrieving the correction factor from a predetermined table (512B) or retrieving the corrected estimation from a predetermined table. The correction may be effected by adding to a logarithmic estimation a logarithmic correction factor. This provides the advantage of improved performance under conditions of low signal to noise ratio (<8dB). SNIR used in power control, alorithm threshold determination etc and applicable to UMTS.

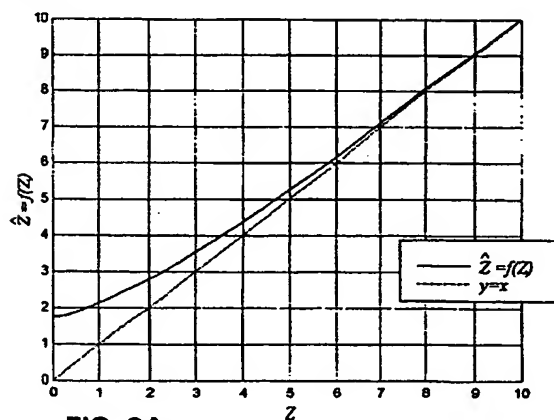


FIG. 3A

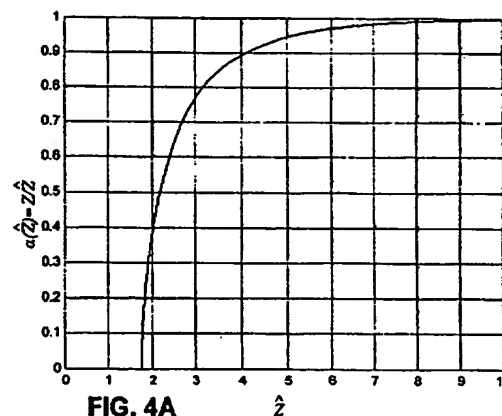


FIG. 4A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

GB 2 382 748 A

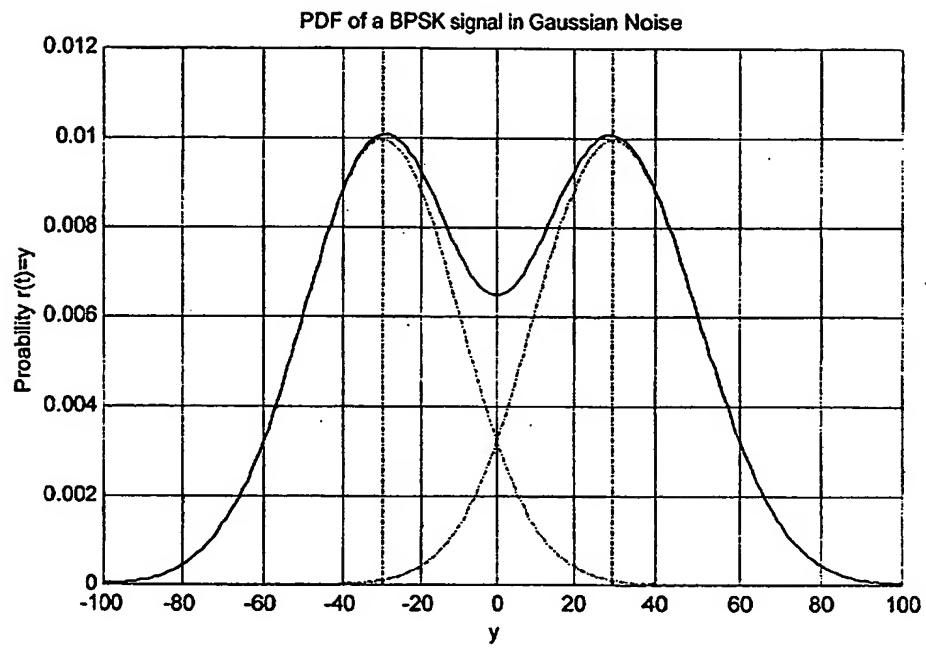


FIG. 1

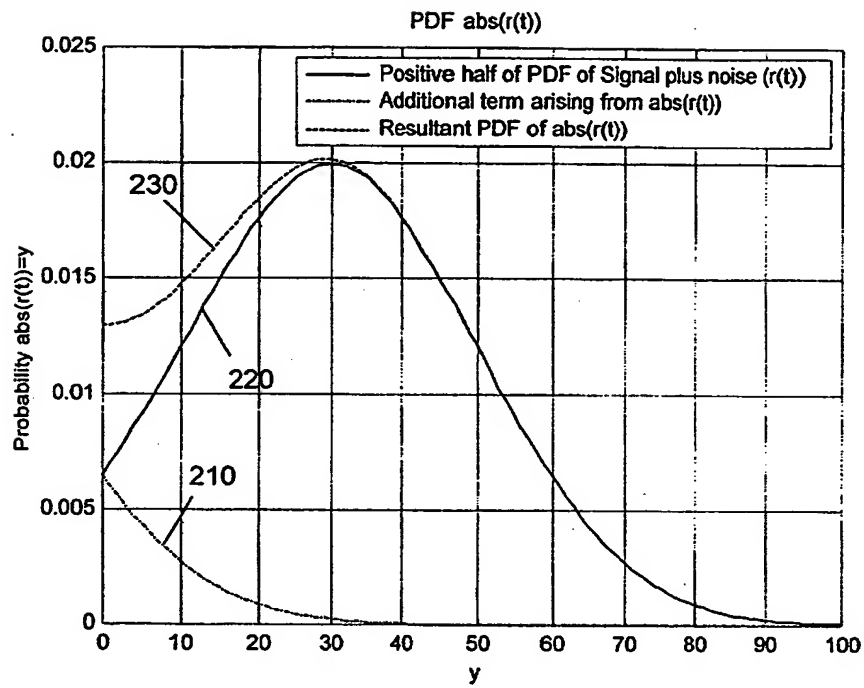


FIG. 2

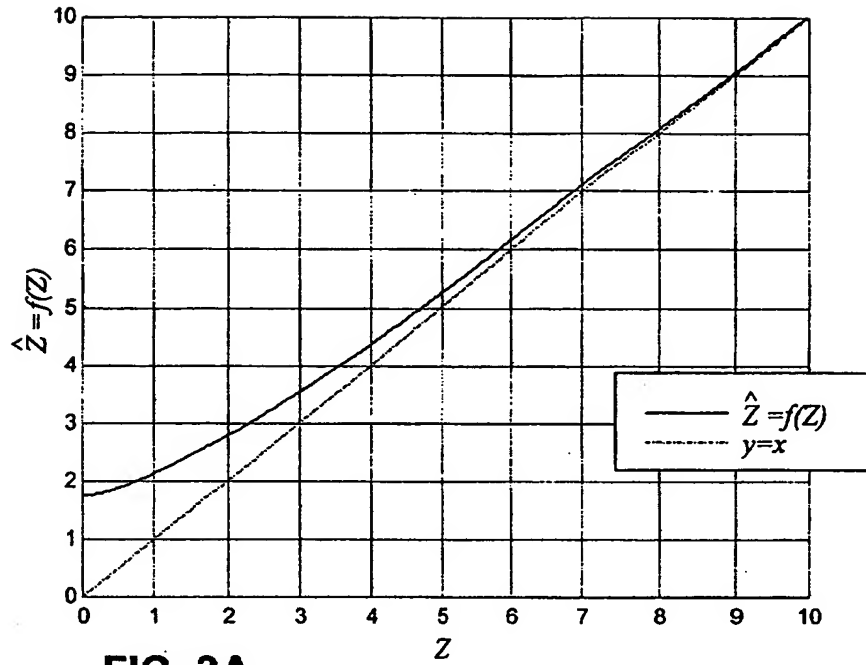
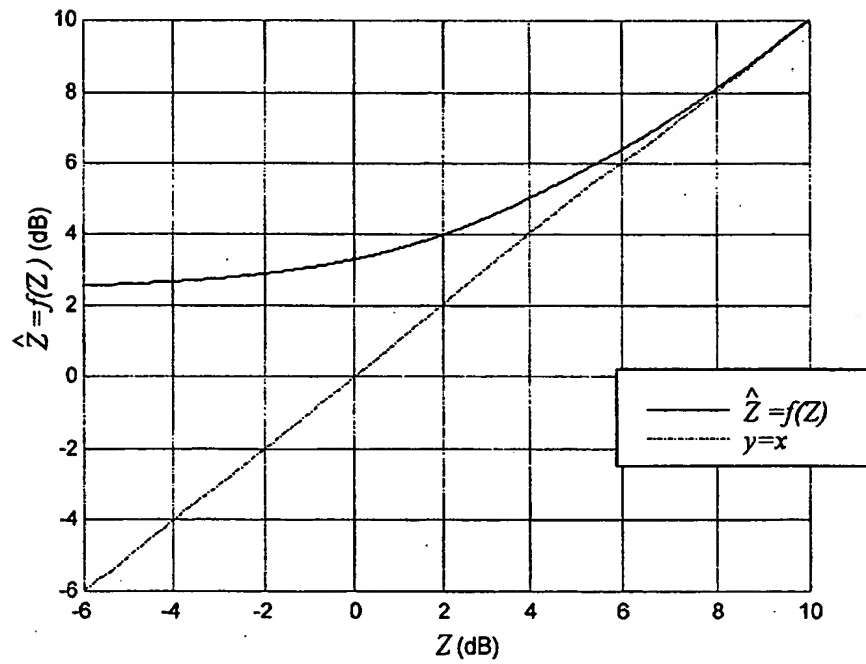
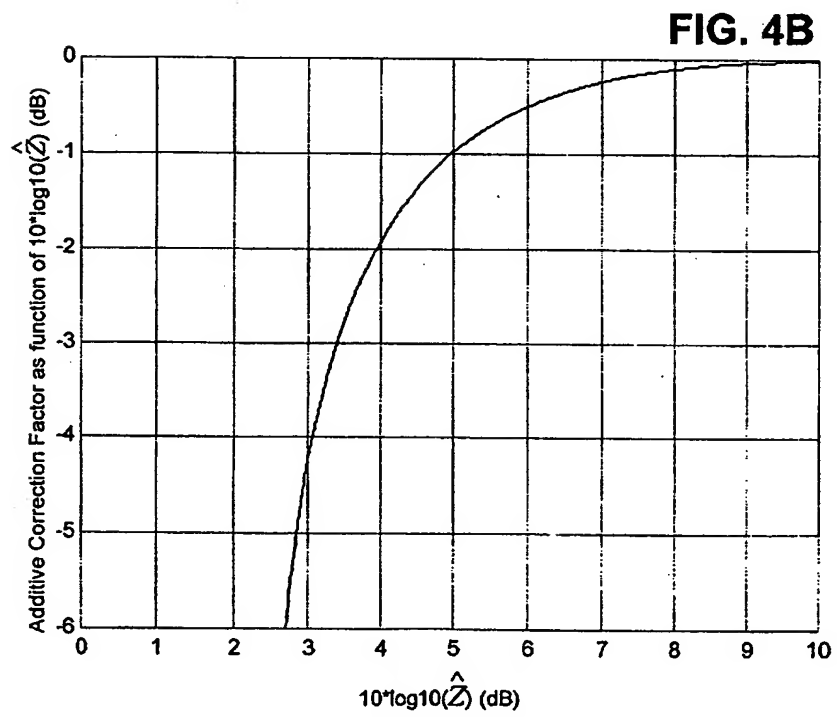
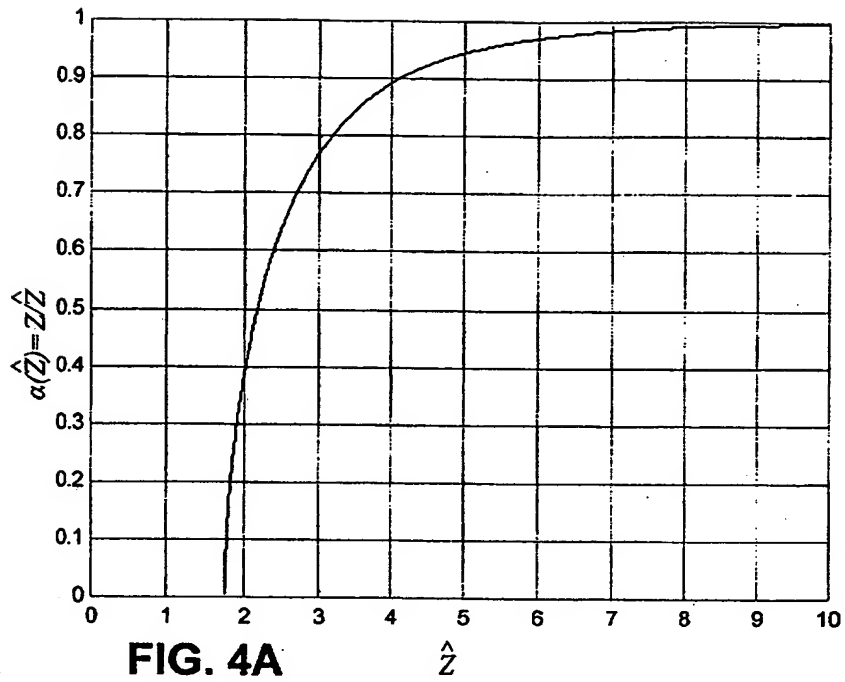


FIG. 3A

FIG. 3B





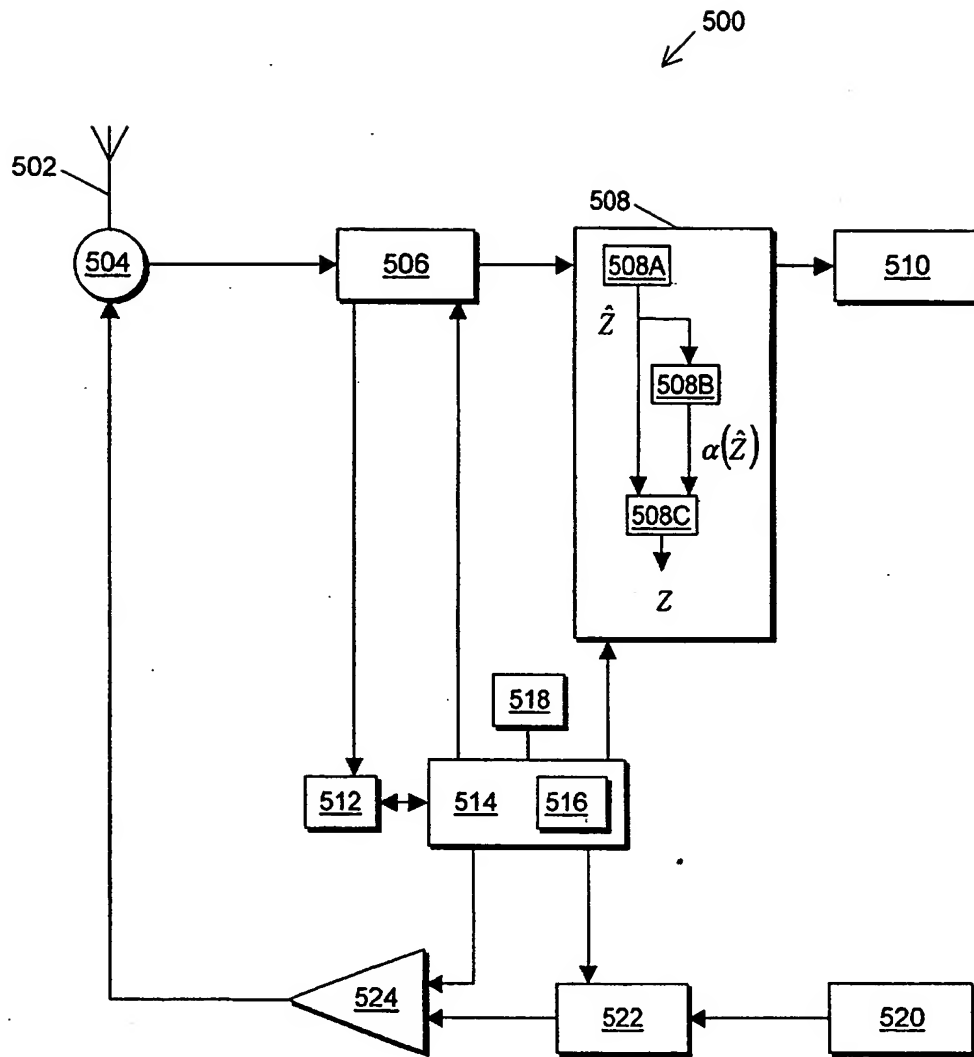


FIG. 5

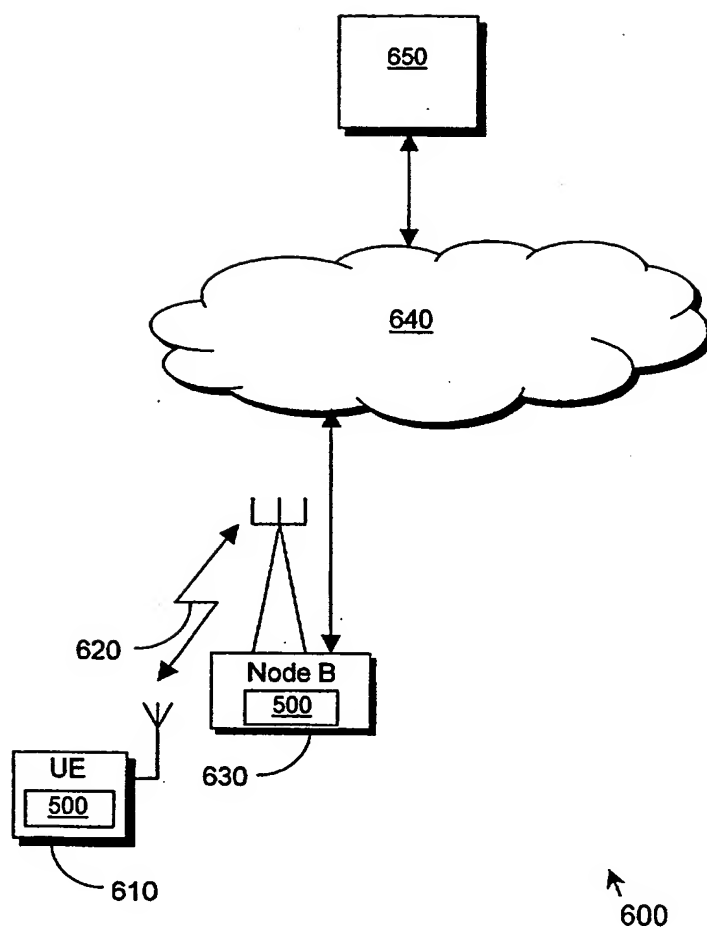


FIG. 6

METHOD, ARRANGEMENT AND COMMUNICATION RECEIVER  
FOR SNIR ESTIMATION

5 **Field of the Invention**

This invention relates to signal to noise/interference ratio (SNIR) estimation, and particularly though not exclusively to such estimation in wireless communication  
 10 receivers.

**Background of the Invention**

15 Many parts of a wireless communications receiver often require an estimation of signal to interference ratio (SIR), signal to noise ratio (SNR), or (more generically to include SIR and/or SNR) noise plus interference ratio (SNIR). This is needed for purposes of power control,  
 20 threshold determination for various algorithms, quantisation of soft-decision information for channel decoding purposes to name but a few.

A well-known SNIR estimation technique derives its  
 25 estimated SNIR  $\hat{Z}$  as

$$\hat{Z} = \frac{[E\{r(t)\}]^2}{E\{r^2(t)\} - [E\{r(t)\}]^2}$$

where E represents mean value and  $r(t)$  represents the combination of signal  $s(t)$  and noise  $n(t)$ .



However, this known estimator suffers from a bias term under conditions of low signal to noise ratio.

A need therefore exists for SNIR estimation wherein the  
5 abovementioned disadvantages may be alleviated.

#### **Statement of Invention**

10 In accordance with a first aspect of the present invention there is provided a method for SNIR estimation as claimed in claim 1.

In accordance with a second aspect of the present  
15 invention there is provided an arrangement for SNIR estimation as claimed in claim 9.

In accordance with a third aspect of the present invention there is provided a communication receiver as  
20 claimed in claim 17.

#### **Brief Description of the Drawings**

25 One method, arrangement and communications receiver for SNIR estimation incorporating the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 shows a graphical representation of the probability density function (PDF) of a received binary-valued signal plus noise;

5        FIG. 2 shows a graphical representation of the positive half of the PDF of FIG. 1, illustrating distortion of the signal power estimate  $\hat{S}$  at low signal to noise ratios;

10       FIG. 3A shows a graphical representation illustrating the relationship of estimated SNIR  $\hat{Z}$  to real SNIR  $Z$ ;

15       FIG. 3B shows, similarly to FIG. 3A, a logarithmic (decibel) graphical representation illustrating the relationship of estimated SNIR  $\hat{Z}$  to real SNIR  $Z$ ;

20       FIG. 4A shows a graphical representation illustrating the relationship of a correction factor  $\alpha(\hat{Z})$  to the uncorrected estimated SNIR  $\hat{Z}$ ;

25       FIG. 4B shows, similarly to FIG. 4A, a logarithmic (decibel) graphical representation illustrating the relationship of the correction factor  $\alpha(\hat{Z})$  to the uncorrected estimated SNIR  $\hat{Z}$ ;

FIG. 5 shows a block-schematic diagram of a wireless communication system receiver in which the invention is used; and

FIG. 6 shows a block-schematic diagram of a UTRA TDD system in which the invention is used.

5

#### Description of Preferred Embodiment

A well-known estimator detects the SNIR of a symmetric binary-valued signal (for example, Binary Phase Shift  
10 Keyed - BPSK), under noise of zero mean. The method is also applicable to QPSK (Quadrature Phase Shift Keyed) signals.

The method considers a BPSK signal  $s(t)$ , which may assume  
15 the value  $\pm A$ . Additive white Gaussian noise (AWGN), denoted  $n(t)$ , is added to this signal.  $n(t)$  has a Gaussian probability density function (PDF) and has a variance (power) of  $\sigma^2$ . The composite signal plus noise is denoted as:

20 
$$r(t) = s(t) + n(t).$$

The PDF of  $r(t)$  takes the form:

$$P\{r(t) = y\} = \frac{1}{\sqrt{2\pi\sigma^2}} \frac{1}{2} \left\{ e^{-\frac{(y+A)^2}{2\sigma^2}} + e^{-\frac{(y-A)^2}{2\sigma^2}} \right\}.$$

This PDF is shown in FIG. 1. This corresponds to the case of  $A=30$  and  $\sigma^2=400$ .

25

The SNIR estimation technique uses the following estimator ( $\hat{S}$ ) for the signal power  $S$ :

$$S = E\{s^2(t)\} \quad \text{and} \quad \hat{S} \equiv [E\{|r(t)|\}]^2.$$

5 The estimate ( $\hat{T}$ ) of the total power ( $T$ ) of  $r(t)$  is:

$$\hat{T} = E\{r^2(t)\}.$$

And so, since  $r(t) = s(t) + n(t)$ , the noise power  $N$  must be equal to the total power minus the signal power:

10 
$$N = T - S.$$

And so the estimate ( $\hat{N}$ ) of the noise power  $N$  is given by:

$$\hat{N} = \hat{T} - \hat{S} = E\{r^2(t)\} - [E\{|r(t)|\}]^2.$$

15

Thus, the signal to noise ratio estimate is:

$$\hat{Z} = \frac{\hat{S}}{\hat{N}} = \frac{\hat{S}}{\hat{T} - \hat{S}} = \frac{[E\{|r(t)|\}]^2}{E\{r^2(t)\} - [E\{|r(t)|\}]^2}.$$

The present invention is based upon the  
 20 realisation by the inventor that the above technique suffers from a bias term for low signal to noise ratio. Due to the use of the "absolute-value" operator, the estimate of the signal amplitude ( $\hat{A}$ ) becomes distorted due to the overlap that occurs between the positive and  
 25 negative portions of the PDF of  $r(t)$ . Hence the signal power estimate ( $\hat{S}$ ) is also distorted. This is shown in

FIG. 2 for a single signalling state (+1) of amplitude  $A$  and power  $S=A^2$ :

Portions of the PDF of  $r(t)$  that cross the line  $r(t)=0$  (as  
5 shown by the line portions 210 and 220) are sign-reversed  
before being accumulated (as shown by the line 230) and  
averaged, and so the estimate of the mean value of  $r(t)$  is  
distorted. In effect, as the signal to noise ratio  
decreases, so the signal power estimate becomes more  
10 over-estimated. The estimate of the total power ( $\hat{T}$ ) is  
however, unaffected. The effect on the overall SNIR  
estimate is the result of  $\hat{S}$  appearing in both the  
numerator and denominator of the equation used to  
calculate  $\hat{Z}$ .

15

This bias offset however, can be shown to be a direct  
function of the real signal to noise ratio ( $Z$ ). Thus, if  
the relationship between  $\hat{Z}$  and  $Z$  is derived and known a  
priori, then the bias may be removed from  $\hat{Z}$  and the true  
20 SNIR ( $Z$ ) may be recovered. Such correction is the basis  
of the present invention.

The mean value of a signal  $x(t)$  is defined as:

$$E\{x(t)\} = \int_{-\infty}^{\infty} y \cdot P\{x(t)=y\} dy$$

25 where  $P\{x(t)=y\}$  is the probability of  $x(t)$  assuming the  
value  $y$ .

By substituting  $|r(t)|$  for  $x(t)$  in the above equation, and by integrating only between 0 and  $\infty$  owing to the fact that  $|r(t)|$  is positive-valued only, we are able to derive the mean value of  $|r(t)|$ . In this case, the probability

5  $P\{|r(t)| = y\}$  is given by:

$$P\{|r(t)| = y\}_{y=0 \rightarrow \infty} = \frac{1}{\sqrt{2\pi\sigma^2}} \left[ e^{-\frac{(y-A)^2}{2\sigma^2}} + e^{-\frac{(y+A)^2}{2\sigma^2}} \right]$$

and so the mean value of  $|r(t)|$  is written as:

$$\hat{A} = E\{|r(t)|\} = \int_0^{\infty} y \cdot \frac{1}{\sqrt{2\pi\sigma^2}} \left[ e^{-\frac{(y-A)^2}{2\sigma^2}} + e^{-\frac{(y+A)^2}{2\sigma^2}} \right] dy$$

10 Evaluating the above integral, the signal amplitude estimate ( $\hat{A}$ ) can be shown to be:

$$\hat{A} = A \left[ 1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc} \left( \sqrt{\frac{Z}{2}} \right) \right]$$

where  $\operatorname{erfc}$  represents the Complementary Error function and

$$Z = \frac{A^2}{\sigma^2}.$$

15

Using this last relationship and the fact that

$$\hat{Z} = \frac{\hat{A}^2}{A^2 + \sigma^2 - \hat{A}^2}, \text{ the required relationship between } \hat{Z} \text{ and } Z$$

can be derived as:

$$\hat{Z} = \frac{\left[ 1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc} \left( \sqrt{\frac{Z}{2}} \right) \right]^2}{1 + 1/Z - \left[ 1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc} \left( \sqrt{\frac{Z}{2}} \right) \right]^2}.$$

$Z$  is plotted against  $\hat{Z}$  in the graph of FIG. 3A.

If the SNIR estimate is expressed in decibels, as is often the case, the graph of FIG. 3A becomes that shown in FIG. 3B.

As can be seen, the error in decibels between the estimated SNIR, and the true SNIR becomes appreciable for real SNIR's of less than approximately 8dB. This therefore limits the usefulness of this SNIR technique, unless the measurement is corrected. By removing the bias in keeping with this invention (as will be explained more fully below), the usefulness of this SNIR estimation technique can be extended to lower SNIR's.

To remove the bias, we assume that  $Z$  can be determined from:

$$Z = \alpha(\hat{Z}) \times \hat{Z}$$

where  $\alpha(\hat{Z})$  is a correction factor as a function of the uncorrected SNIR estimate  $\hat{Z}$  and may be determined by plotting  $\hat{Z}$  against  $(Z/\hat{Z})$  as shown in FIG. 4A.

$\alpha(\hat{Z})$  may therefore be either (i) calculated from  $\hat{Z}$  or may be (ii) stored in tabulated form for 'look-up' in order to facilitate the evaluation of the true SNIR  $Z$ . Alternatively, it will be understood, (iii) a table may hold corrected values of  $Z$  and the uncorrected estimated value  $\hat{Z}$  may serve as a pointer to the table to 'look-up' the corrected value. It will be understood that all

three such correction techniques are different implementations of the same underlying correction scheme based on the corrected SNIR estimate  $Z$  being a predefined function (as described above) of the uncorrected SNIR  
5 estimate  $\hat{Z}$ .

In terms of a logarithmic correction factor  $\Gamma\{10.\log_{10}(\hat{Z})\}$  to be added to  $10.\log_{10}(\hat{Z})$  in order to derive  $10.\log_{10}\{Z\}$ , the relationship shown in FIG. 4B may be inferred, such that:  
10 
$$10.\log_{10}(Z) = 10.\log_{10}(\hat{Z}) + \Gamma(10.\log_{10}(\hat{Z})).$$

It is recognised that as the SNIR is reduced towards zero, so  $\hat{Z}$  tends asymptotically towards approximately 1.75. At these low SNIR's, small variations in  $\hat{Z}$  produce  
15 large variations in  $Z$ . As such, this technique has limitations at very low SNIR's since a highly accurate measurement of  $\hat{Z}$  is required. This would require a large number of samples to be used in the computation of  $\hat{Z}$  which may not be available in practical circumstances.  
20 However, this technique is able to significantly reduce the bias effects of the prior art SNIR estimation technique for the SNIR range between approximately 0 and 8dB.

25 The corrected estimation technique described above may be used in a receiver in wireless communication system such as UTRA TDD (UMTS - Universal Mobile Telecommunication System - Terrestrial Radio Access in Time Division Duplex mode). Such a receiver, which may be a mobile



transceiver unit (commonly referred to in UMTS terminology as User Equipment - UE) or a base station transceiver unit (commonly referred to in UMTS terminology as a Node B) is shown in block schematic form in FIG. 5. The transceiver unit 500 contains an antenna 502 coupled to a duplex filter or circulator 504 that provides isolation between receive and transmit chains within the transceiver unit.

10 The receiver chain, as known in the art, includes scanning receiver front-end circuitry 506 (effectively providing reception, filtering and intermediate or base-band frequency conversion). The scanning front-end circuit is serially coupled to a signal processing  
15 function 508, in which the invention may be implemented as will be described in greater detail below.

An output from the signal processing function is provided to output 510, which comprises either: an interface for  
20 communicating with a radio network controller if the communication unit is a Node B, or an interface for communicating with (for example) a user display if the communication unit is a UE.

25 The receiver chain also includes a received signal strength indicator (RSSI) module 512 and a controller 514 that operates to maintain overall control of the different functions and modules of the communication unit 500. The controller 514 is also coupled to the scanning  
30 receiver front-end circuitry 506 and the signal

processing function 508 (generally realised by a digital signal processor, i.e. DSP).

5 The controller 514 includes a memory 516 that stores operating regimes, such as decoding and other receiving operations. A timer 518 is typically coupled to the controller 514 to control the timing of operations (transmission or reception of time-dependent signals) within the communication unit 500.

10

As regards the transmit chain, this includes an input 520, which comprises either: an interface for communicating with a radio network controller if the communication unit is a Node B, or an interface for  
15 receiving user input if the communication unit is a UE. The input 520 is coupled in series through transmitter/modulation circuitry 522 and a power amplifier 524 to the antenna 502. The transmitter/modulation circuitry 522 and the power  
20 amplifier 524 are operationally responsive to the controller.

It will be understood that in this embodiment the controller 514 including memory 516 is implemented as a  
25 programmable processor, but in other embodiments can comprise dedicated circuitry or any other suitable form.

It is noted that corresponding features to those described above with respect to the communication unit  
30 500 are also found in conventional Node B's. However, the communication unit 500 of this embodiment differs

over conventional communication units by virtue that the signal processing function 508 is arranged to implement the corrected estimation technique described above.

5 The signal processing function 508 includes circuitry (not shown) for quantisation of soft-decision information for channel decoding purposes (e.g., using a Viterbi decoder - not shown - to decode symbols in a received signal). Accurate estimation of the SNIR of the received  
10 signal improves the accuracy of the soft-decision in respect of decoded symbols, and also enhances the error-correcting ability of the channel decoder. In order to implement the corrected estimation technique described above, the signal processing function 508 includes  
15 circuitry 508A for deriving the received signal's uncorrected SNIR  $\hat{Z}$ , as known in the prior art described above. Additionally, a table 508B for looking up the correction factor  $\alpha(\hat{Z})$  (as explained above in relation to FIG. 4A and 4B) is included. The signal processing  
20 function 508 also includes a processor 508C for applying the correction factor to the uncorrected SNIR  $\hat{Z}$  to produce the corrected SNIR  $Z$ , as described above.

It will be understood that in practice the look-up table  
25 508B may be provided within the memory 516 in the controller 514, and that the processor 508C may be provided by the controller 514). It will also be understood that if it is not desired to implement correction of the estimated SNIR by way of a look-up  
30 table 512B, the correction factor  $\alpha(\hat{Z})$  may be calculated

(e.g., by the controller 514) in accordance with the above-discussed equation:

$$\hat{Z} = \frac{\left[1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right)\right]^2}{1 + 1/Z - \left[1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right)\right]^2}$$

5 Although in the above example the corrected estimation technique of the invention is implemented for purposes of quantisation of soft-decision information for channel decoding purposes, it may alternatively or additionally be implemented for purposes of power control, threshold  
10 determination for various algorithms, etc., and may be implemented at the output of a correlator, a joint detector, or other detector.

Referring now also to FIG. 6, a UTRA TDD system 600  
15 includes a UE 610 which communicates over a CDMA radio air interface 620 with a Node B 630. The Node B 630 is controlled by a radio network controller 640, which communicates with other system infrastructure shown collectively as 650. Such a system (insofar as it has  
20 been described up to this point) is well known and need not be described further. However, it will be understood that the communication unit 500 described above for deriving a corrected SNIR estimation may be advantageously implemented in either a UE 610 or a Node B  
25 630 of the system as shown in the figure.

It will be appreciated that the method described above for SNIR estimation of a received signal may be carried out in software running on a processor (such as the processor in which the controller 514 and the memory 516 is implemented), and that the software may be provided as a computer program element carried on any suitable data carrier (also not shown) such as a magnetic or optical computer disc.

10 It will be also be appreciated that the method described above for SNIR estimation of a received signal may alternatively be carried out in hardware, for example in the form of an integrated circuit (not shown) such as an FPGA (Field Programmable Gate Array) or ASIC (Application  
15 Specific Integrated Integrated Circuit).

In conclusion, therefore, it will be understood that the scheme for SNIR estimation described above provides the following advantages:

20

Enables non-biased direct SNIR estimation on a single or binary-valued signal in the presence of additive white Gaussian noise.

25

Extends the useful range of the method detailed in prior-art into the medium-low SNIR range 0-8dB, in which the technique detailed in the prior art would suffer significant measurement bias.

# Claims

1. A method for SNIR estimation of a received signal, the method comprising:

- 5 deriving an estimation  $\hat{Z}$  of SNIR of the received signal in accordance substantially with the relation

$$\hat{Z} = \frac{[E\{r(t)\}]^2}{E\{r^2(t)\} - [E\{r(t)\}]^2},$$

where E represents mean value and  $r(t)$  represents the level of the received signal; and

- 10 correcting the estimation  $\hat{Z}$  to produce a corrected estimation Z based on substantially the relation

$$Z = \alpha(\hat{Z}) \times \hat{Z},$$

where  $\alpha(\hat{Z})$  represents a correction factor.

- 15 2. The method of claim 1 wherein the relation

$$Z = \alpha(\hat{Z}) \times \hat{Z}$$

is based on substantially the relation

$$\hat{Z} = \frac{\left[1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right)\right]^2}{1 + 1/Z - \left[1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right)\right]^2}.$$

- 20 3. The method of claim 1 or 2 wherein the estimation of SNIR is a logarithmic quantity and the step of correcting the estimation comprises adding a logarithmic correction factor to the estimation  $\hat{Z}$  to produce a corrected estimation Z.

4. The method of claim 1, 2 or 3 wherein the step of correcting the estimation comprises calculating the correction factor.
- 5
5. The method of claim 1, 2 or 3 wherein the step of correcting the estimation comprises retrieving the correction factor from a predetermined table.
- 10
6. The method of claim 1, 2 or 3 wherein the step of correcting the estimation comprises retrieving the corrected estimation from a predetermined table.
- 15
7. The method of any preceding claim wherein the received signal is a wireless signal.
8. The method of claim 7 wherein the wireless signal is a UMTS air interface signal.
- 20
9. An arrangement for SNIR estimation of a received signal, the arrangement comprising:
- means for deriving an estimation  $\hat{Z}$  of SNIR of the received signal in accordance substantially with the relation
- 25
- $$\hat{Z} = \frac{[E\{r(t)\}]^2}{E\{r^2(t)\} - [E\{r(t)\}]^2},$$
- where E represents mean value and  $r(t)$  represents the level of the received signal; and

means for correcting the estimation  $\hat{Z}$  to produce a corrected estimation  $Z$  based on substantially the relation

$$Z = \alpha(\hat{Z}) \times \hat{Z},$$

5 where  $\alpha(\hat{Z})$  represents a correction factor.

10. The arrangement of claim 9 wherein the relation

$$Z = \alpha(\hat{Z}) \times \hat{Z}$$

is based on substantially the relation

10

$$\hat{Z} = \frac{\left[ 1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right) \right]^2}{1 + 1/Z - \left[ 1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right) \right]^2}.$$

11. The arrangement of claim 9 or 10 wherein the estimation of SNIR is a logarithmic quantity and the means for correcting the estimation comprises means for  
15 adding a logarithmic correction factor to the estimation  $\hat{Z}$  to produce a corrected estimation  $Z$ .

12. The arrangement of claim 9, 10 or 11 wherein the means for correcting the estimation comprises means for  
20 calculating the correction factor.

13. The arrangement of claim 9, 10 or 11 wherein the means for correcting the estimation comprises means for  
25 retrieving the correction factor from a predetermined table.



14. The arrangement of claim 9, 10 or 11 wherein the means for correcting the estimation comprises means for retrieving the corrected estimation from a predetermined table.

5

15. The arrangement of any one of claims 8 to 14 wherein the received signal is a wireless signal.

16. The arrangement of claim 15 wherein the wireless  
10 signal is a UMTS air interface signal.

17. A communication receiver comprising the arrangement of any one of claims 9 to 16.

15 18. User equipment for use in a wireless communication system, the user equipment comprising the communication receiver of claim 17.

19. A base station for use in a wireless communication  
20 system, the base station comprising the communication receiver of claim 17.

20. A computer program element comprising computer  
program means for performing the method of any one of  
25 claims 1 to 8.

21. An integrated circuit comprising the arrangement of any one of claims 9 to 16.

22. A method, for SNIR estimation of a received signal, substantially as hereinbefore described with reference to the accompanying drawings.
- 5 23. An arrangement for SNIR estimation of a received signal substantially as hereinbefore described with reference to the accompanying drawings.

Amendments to the claims have been filed as follows

### Claims

1. A method for SNIR estimation of a received signal, the method comprising:

- 5 deriving an estimation signal  $\hat{Z}$  of SNIR of the received signal in accordance substantially with the relation

$$\hat{Z} = \frac{[E\{r(t)\}]^2}{E\{r^2(t)\} - [E\{r(t)\}]^2},$$

10 where E represents mean value and  $r(t)$  represents the level of the received signal; and

correcting the estimation signal  $\hat{Z}$  to produce a corrected estimation signal Z based on substantially the relation

$$Z = \alpha(\hat{Z}) \times \hat{Z},$$

- 15 where  $\alpha(\hat{Z})$  represents a correction factor.

2. The method of claim 1 wherein the relation

$$Z = \alpha(\hat{Z}) \times \hat{Z}$$

is based on substantially the relation

20 
$$\hat{Z} = \frac{\left[1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right)\right]^2}{1 + 1/Z - \left[1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right)\right]^2}.$$

3. The method of claim 1 or 2 wherein the estimation signal of SNIR is a logarithmic quantity and the step of correcting the estimation signal comprises adding a

logarithmic correction factor to the estimation signal  $\hat{Z}$  to produce a corrected estimation signal  $Z$ .

4. The method of claim 1, 2 or 3 wherein the step of  
5 correcting the estimation signal comprises calculating the correction factor.
5. The method of claim 1, 2 or 3 wherein the step of  
correcting the estimation signal comprises retrieving the  
10 correction factor from a predetermined table.
6. The method of claim 1, 2 or 3 wherein the step of  
correcting the estimation signal comprises retrieving the  
corrected estimation from a predetermined table.  
15
7. The method of any preceding claim wherein the  
received signal is a wireless signal.
8. The method of claim 7 wherein the wireless signal is  
20 a UMTS air interface signal.
9. An arrangement for SNIR estimation of a received  
signal, the arrangement comprising:  
means for deriving an estimation  $\hat{Z}$  of SNIR of the  
25 received signal in accordance substantially with the  
relation

$$\hat{Z} = \frac{[E\{r(t)\}]^2}{E\{r^2(t)\} - [E\{r(t)\}]^2},$$

where  $E$  represents mean value and  $r(t)$  represents the level of the received signal; and

means for correcting the estimation  $\hat{Z}$  to produce a corrected estimation  $Z$  based on substantially the relation

$$Z = \alpha(\hat{Z}) \times \hat{Z},$$

5 where  $\alpha(\hat{Z})$  represents a correction factor.

10. The arrangement of claim 9 wherein the relation

$$Z = \alpha(\hat{Z}) \times \hat{Z}$$

is based on substantially the relation

$$10 \quad \hat{Z} = \frac{\left[ 1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right) \right]^2}{1 + 1/Z - \left[ 1 + \sqrt{\frac{2}{\pi Z}} e^{-Z/2} - \operatorname{erfc}\left(\sqrt{\frac{Z}{2}}\right) \right]^2}.$$

11. The arrangement of claim 9 or 10 wherein the estimation of SNIR is a logarithmic quantity and the means for correcting the estimation comprises means for  
15 adding a logarithmic correction factor to the estimation  $\hat{Z}$  to produce a corrected estimation  $Z$ .

12. The arrangement of claim 9, 10 or 11 wherein the means for correcting the estimation comprises means for  
20 calculating the correction factor.

13. The arrangement of claim 9, 10 or 11 wherein the means for correcting the estimation comprises means for  
25 retrieving the correction factor from a predetermined table.

14. The arrangement of claim 9, 10 or 11 wherein the means for correcting the estimation comprises means for retrieving the corrected estimation from a predetermined table.
- 5
15. The arrangement of any one of claims 8 to 14 wherein the received signal is a wireless signal.
16. The arrangement of claim 15 wherein the wireless
- 10 signal is a UMTS air interface signal.
17. A communication receiver comprising the arrangement of any one of claims 9 to 16.
- 15 18. User equipment for use in a wireless communication system, the user equipment comprising the communication receiver of claim 17.
19. A base station for use in a wireless communication
- 20 system, the base station comprising the communication receiver of claim 17.
20. A computer program element comprising computer
- 25 program means for performing the method of any one of claims 1 to 8.
21. An integrated circuit comprising the arrangement of any one of claims 9 to 16.





INVESTOR IN PEOPLE

Application No: GB 0128475.1  
Claims searched: 1-21

Examiner: Anita Keogh  
Date of search: 4 September 2002

## Patents Act 1977 Search Report under Section 17

### Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:  
UK Cl (Ed.T): H4L (LDTP, LFMA, LFMX), H4P (PEM)  
Int Cl (Ed.7): H04B (1/10, 1/707, 7/005, 7/08, 17/00), H04L (1/20), H04Q (7/32, 7/38)  
Other: Online: WPI, JAPIO, EPODOC, INSPEC

### Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A, E	WO 02/25853 A2 (IOSPAN) see abstract and especially page 10 lines 26-29 and page 22 lines 11-19	1, 3, 4, 7, 9, 11, 12, 15, 17-21
X	WO 01/82521 A1 (QUALCOMM) see abstract and equations 1 & 2	1, 9 at least
A	WO 01/20789 A1 (QUALCOMM) see abstract	-
X	WO 99/46869 A1 (ERICSSON) see abstract and whole document	1, 9 at least
X	US 6028894 (OISHI et al.) see column 11 lines 16-38 and column 12 lines 31-36	1, 9 at least
A	US 5737365 (GILBERT et al.) see abstract and column 8 line 29 - column 9 line 62	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.